

(12) NACH DEM VERTRAG ÜBER DIE INTERNATIONALE ZUSAMMENARBEIT AUF DEM GEBIET DES
PATENTWESENS (PCT) VERÖFFENTLICHTE INTERNATIONALE ANMELDUNG

(19) Weltorganisation für geistiges Eigentum
Internationales Büro



(43) Internationales Veröffentlichungsdatum
18. Oktober 2001 (18.10.2001)

PCT

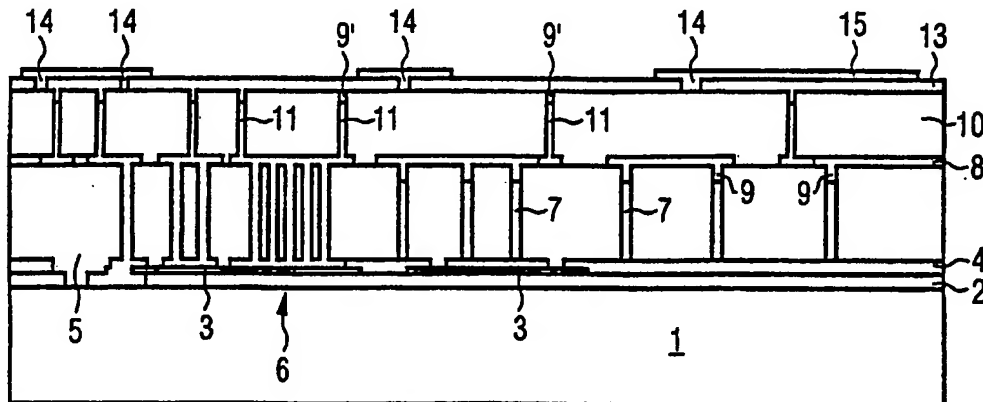
(10) Internationale Veröffentlichungsnummer
WO 01/77009 A1

- (51) Internationale Patentklassifikation⁷: B81C 1/00, (71) Anmelder (für alle Bestimmungsstaaten mit Ausnahme von
B81B 3/00 US): ROBERT BOSCH GMBH [DE/DE]; Postfach 30 02
20, 70442 Stuttgart (DE).
- (21) Internationales Aktenzeichen: PCT/DE01/00921 (72) Erfinder; und
(75) Erfinder/Anmelder (nur für US): LUTZ, Markus
(22) Internationales Anmeldedatum: 10. März 2001 (10.03.2001) [DE/US]; Mahagony Lane 762, Sunnyvale, CA 94086
(US).
- (25) Einreichungssprache: Deutsch (81) Bestimmungsstaaten (national): JP, US.
- (26) Veröffentlichungssprache: Deutsch (84) Bestimmungsstaaten (regional): europäisches Patent (AT,
BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC,
(30) Angaben zur Priorität: 100 17 422.1 7. April 2000 (07.04.2000) DE NL, PT, SE, TR).

[Fortsetzung auf der nächsten Seite]

(54) Title: MICROMECHANICAL COMPONENT AND METHOD FOR PRODUCING THE SAME

(54) Bezeichnung: MIKROMECHANISCHES BAUELEMENT UND ENTSPRECHENDES HERSTELLUNGSVERFAHREN



(57) Abstract: The invention relates to a method for producing a micromechanical component, comprising the following steps: providing a substrate (1); providing a first micromechanical functional layer (5) on the sacrificial coating (4); structuring the first micromechanical functional layer (5) in such a manner that it is provided with a mobilizable sensor structure (6); providing and structuring a first sealing layer (8) on the structured first micromechanical functional layer (5); providing and structuring a second micromechanical functional layer (10) on the first sealing layer (8) that has at least a covering function and that is at least partially anchored in the first micromechanical functional layer (5); mobilizing the sensor structure (6); and providing a second sealing layer (8) on the second micromechanical functional layer (10). The invention further relates to a corresponding micromechanical component.

(57) Zusammenfassung: Die Erfindung schafft ein Verfahren zur Herstellung eines mikromechanischen Bauelementes mit den Schritten: Bereitstellen eines Substrats (1); Vorsehen einer ersten mikromechanischen Funktionsschicht (5) auf der Opferschicht (4); Strukturieren der ersten mikromechanischen Funktionsschicht (5) derart, daß sie eine beweglich zu machende Sensorstruktur (6) aufweist; Vorsehen und Strukturieren einer ersten Verschlussschicht (8) auf der strukturierten ersten mikromechanischen Funktionsschicht (5); Vorsehen und Strukturieren einer zweiten mikromechanischen Funktionsschicht

[Fortsetzung auf der nächsten Seite]

WO 01/77009 A1

R37102

[10191/2770]

MICROMECHANICAL COMPONENT AND METHOD OF MANUFACTURING
A MICROMECHANICAL COMPONENT

FIELD OF THE INVENTION

The present invention relates to a micromechanical component having a substrate and a movable sensor structure in a first micromechanical functional layer on a sacrificial layer. The present invention also relates to a corresponding manufacturing method.

Although it may be applicable to any micromechanical components and structures, in particular to sensors and actuators, the present invention and the underlying problem are elucidated with reference to a micromechanical component, e.g., an acceleration sensor, that is manufacturable using silicon surface micromechanical technology.

BACKGROUND INFORMATION

Monolithically integrated inertial sensors may be manufactured by surface micromechanical technology in which the sensitive movable structures are arranged on the chip without protection (analog devices). This may result in increased expenses for handling and packaging.

This problem may be circumvented by a sensor, the structures manufactured by surface micromechanics being covered by a second cap wafer. This type of packaging may be responsible for a large share (such as, for example, approximately 75%) of the cost of manufacturing an acceleration sensor by surface micromechanical technology. These costs may arise as a result of the high surface area requirements of the sealing surface between the cap wafer and the sensor wafer and due to the complex structuring (2-3 masks, bulk micromechanics) of the cap

wafer.

5 The structure of a functional layer system and a method
for hermetic capping of sensors using surface
micromechanics is described in German Published Patent
Application No. 195 37 814. The manufacture of the sensor
structure using technological methods is explained. The
cited hermetic capping is performed using a separate cap
10 wafer made of silicon, which is structured using
structuring processes such as KOH etching, that may be
expensive. The cap wafer is applied to the substrate with
the sensor (sensor wafer) using a seal glass. This may
require a wide bonding frame around each sensor chip to
ensure an adequate adhesion and sealing ability of the
15 cap. This may limit the number of sensor chips per sensor
wafer considerably. Due to the large amount of space
required and the expense of manufacture of the cap wafer,
sensor capping may incur considerable costs.

20 SUMMARY OF THE INVENTION

An exemplary manufacturing method of the present
invention may have the following features.

25 It may build on a prior surface micromechanical method
which creates epitaxial polysilicon of a thickness of at
least 10 μm to form a micromechanical functional layer. A
novel permeable layer may not be required but rather
other prior processes may be used. A novel feature may
include the step to produce the sealing layers which have
30 a sealing and leveling function.

As a result, the surface micromechanical method may be
simplified since the cap wafer may not be required due to
the second micromechanical functional layer which may
35 perform at least one cover function and the structures
which may be contacted from above.

In addition, the functionality of the process may be enhanced, i.e., additional mechanical and/or electrical components to implement the component may be available to the designer. The following functional elements in particular may be created:

- a pressure sensor diaphragm in the second micromechanical functional layer;
- a printed conductor structure in the second micromechanical functional layer which is capable of crossover with an additional printed conductor structure provided above the second sealing layer;
- very low-resistance aluminum leads in the additional printed conductor structure provided above the second sealing layer;
- a vertical differential capacitor;
- additional anchor points of the structures of the first micromechanical functional layer in the second micromechanical functional layer.

Other prior IC packaging methods such as hybrid, plastic, flip-chip, etc. may also be used.

According to an exemplary refinement, a sacrificial layer may be provided on the substrate and the sacrificial layer may be etched to mobilize the sensor structure. In a simplified version, the substrate may be provided with a sacrificial layer and the first micromechanical functional layer may be provided as a silicon-on-insulator (SOI) structure.

According to another exemplary refinement, the first micromechanical functional layer may be structured so

that it has passages extending to the sacrificial layer. Furthermore, the second micromechanical functional layer may be structured so that it has second passages extending to the first sealing layer, the second passages being connected to the first sealing layer by connection areas. The first sealing layer may then be etched to remove the connection areas using the second passages as etch channels. Finally, the sacrificial layer may be etched using the first and second passages connected together by the removal of the connection areas. This may minimize the cost of the etching processes since the sacrificial layer and the first sealing layer may be etched in one step.

Thus, etch channels running through the first and second micromechanical functional layer and the intermediate first sealing layer may be produced to remove the optionally provided sacrificial layer. Therefore, the thickness of the second micromechanical functional layer may be increased and its strength or stiffness may be improved. As a consequence, large areas may be spanned and the components may be exposed to greater stress. When removing the sacrificial layer, the aluminum of the printed conductors or the like may not be a concern since it may not be applied until a later point in time.

According to another exemplary refinement, a buried polysilicon layer is provided below the first or second micromechanical functional layer. The buried polysilicon and an insulation layer lying below it may be dispensed with since additional wiring levels above the sensor structure may be available.

According to another exemplary refinement, the first and second sealing layer may be configured substantially thinner than the first and second micromechanical functional layer.

According to another exemplary refinement, the first and/or second sealing layers may be provided by a non-conforming deposition so that only the upper areas of the first and second passages, respectively, are obstructed. This may reduce the etching time for removal of the sacrificial layer since only a portion of the passages may be obstructed.

According to another exemplary refinement, the first and/or second passages may be configured as trenches or holes which narrow toward the top.

According to another exemplary refinement, the first and/or second micromechanical functional layers may be made of a conductive material, such as, for example, polysilicon.

According to another exemplary refinement, the first and/or second sealing layers may be made of a dielectric material, such as, for example, silica.

According to another exemplary refinement, one or more printed conductor layers, such as, for example, layers made of aluminum, may be provided on the second sealing layer.

According to another exemplary refinement, a printed conductor structure may be integrated into the second micromechanical functional layer.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows a schematic cross-sectional view of a micromechanical component according to a first exemplary embodiment of the present invention in a first process stage.

Figure 2 shows a schematic cross-sectional view of the

micromechanical component according to the first exemplary embodiment of the present invention in a second process stage.

5 Figure 3 shows a schematic cross-sectional view of the micromechanical component according to the first exemplary embodiment of the present invention in a third process stage.

10 Figure 4 shows a schematic cross-sectional view of the micromechanical component according to the first exemplary embodiment of the present invention in a fourth process stage.

15 Figure 5 shows an enlarged detail of the schematic cross-sectional view of the micromechanical component according to the first exemplary embodiment of the present invention as shown in Figure 4.

20 DETAILED DESCRIPTION

In the figures, identical reference symbols denote identical or functionally equivalent components.

25 Figure 1 shows a schematic cross-sectional view of a micromechanical component according to a first exemplary embodiment of the present invention in a first process stage.

30 In Figure 1, 1 denotes a silicon substrate wafer, 2 a lower oxide, 3 a buried polysilicon layer, 4 a sacrificial oxide, 20 a contact hole in lower oxide 2 and 21 denotes contact holes in sacrificial oxide 4.

35 In order to manufacture the structure shown in Figure 1, lower oxide 2 is first deposited on the entire surface of silicon substrate wafer 1. In a subsequent step, polysilicon is deposited and structured to produce

printed conductors in buried polysilicon layer 3.

Subsequently, sacrificial oxide 4 is applied to the entire surface of the overall structure using, for example, a low-temperature oxide (LTO) method or a tetraethyl orthosilicate (TEOS) method. Then contact holes 20 and 21 are created at the intended locations using conventional photomethods and etching methods.

Figure 2 shows a schematic cross-sectional view of the micromechanical component according to the first exemplary embodiment of the present invention in a second process stage.

In addition to the reference symbols already introduced in Figure 2, 5 denotes a first micromechanical functional layer in the form of an epitaxial polysilicon layer, 6 a sensor structure (comb structure) to be mobilized later, 7 trenches in first micromechanical functional layer 5, 8 a first sealing oxide (LTO, TEOS or the like), 9 plugs in trenches 7 made of sealing oxide 8, 16 oxide connection areas for the later sacrificial oxide etching and 22 contact holes in sealing oxide 8.

To manufacture the structure shown in Figure 2, epitaxial polysilicon is first deposited in a conventional manner to form first micromechanical functional layer 5 and micromechanical functional layer 5 is structured to form sensor structure 6 to be mobilized and trenches 7.

This is followed by a refill process to seal trenches 7 using sealing oxide 8 and subsequent optional planarization. Although it is not mentioned explicitly below, such planarization may in principle be performed after each layer deposition on the entire surface.

In the example shown, the refill is not complete but

rather covers 100% of the underlying structure upward only and also provides a seal. This is shown in greater detail in Figure 5.

5 A process follows to form contact holes 22 by conventional photomethods and etching methods. These contact holes 22 are used to anchor second micromechanical functional layer 10 to be applied later (see Figure 3) and to limit oxide connection areas 16 for
10 later sacrificial oxide etching.

Figure 3 shows a schematic cross-sectional view of the micromechanical component according to the first exemplary embodiment of the present invention in a third
15 process stage.

In addition to the reference symbols already introduced in Figure 3, 10 denotes a second micromechanical functional layer in the form of an epitaxial polysilicon layer and 11 denotes trenches in second micromechanical
20 functional layer 10.

To form the structure shown in Figure 3, second micromechanical functional layer 10 is deposited in a
25 manner similar to first micromechanical functional layer 5 as a stable sealing layer for underlying sensor structure 6. In addition to this sealing function, second micromechanical functional layer 10 may of course also be used for contacting, as a feed, as an upper electrode,
30 etc. for the component. This layer 10 is then structured to produce trenches 11 which are later required together with trenches 9 for the sacrificial oxide etching.

Figure 4 shows a schematic cross-sectional view of the micromechanical component according to the first
35 exemplary embodiment of the present invention in a fourth process stage.

In addition to the reference symbols already introduced in Figure 4, 13 denotes a second sealing oxide (LTO, TEOS or the like), 14 a contact hole in sealing oxide 13, 15 a printed conductor level made of aluminum which is
5 connected to second micromechanical functional layer 10 via contact holes 14.

Starting from the process stage shown in Figure 3, the following steps may be performed to achieve the process stage according to Figure 4. First, sealing oxide 8 is
10 etched to remove oxide connection areas 16 using second trenches 11 as etch channels. Sacrificial layer 4 is then etched using first and second trenches 7, 11 connected together by removing connection areas 16 as etch
15 channels. A long sacrificial oxide etching is possible since no aluminum is present on the surface at this time.

In a subsequent process step, a second refill process forms second sealing oxide 13, this deposition also not
20 being a conforming deposition but rather only the surfaces of trenches 11 are occluded. This is illustrated in greater detail in Figure 5. The internal pressure or internal atmosphere contained in sensor structure 6 is a function of the process conditions of the refill process.
25 These parameters determine, e.g., the damping of the sensor structure.

Second sealing oxide 13 is then structured to form contact holes 14 and printed conductor level 15 made of
30 aluminum is deposited and structured.

Although the present invention has been described above on the basis of an exemplary embodiment, it is not
35 limited to it but instead is modifiable in a variety of ways.

In particular, any micromechanical base materials such

as, e.g., germanium may be used and not only the silicon substrate cited as an example.

5 Also, any sensor structures may be formed and not only the acceleration sensor illustrated.

10 Although not shown in the figures, trenches 7 and 11 may be configured to narrow toward the top in order to promote the non-conforming deposition of first and second sealing layers 8, 13.

15 The layer thicknesses of first and second micromechanical functional layer 5, 10 may be varied by the epitaxial and planarization process in a simple manner since the sacrificial layer etching is not a function of the permeability of the second micromechanical functional layer.

20 Of course, the micromechanical functional layer/sealing layer sequence may be repeated and a buried printed conductor may be provided under each micromechanical functional layer above the underlying micromechanical functional layer.

25 Finally, additional wiring levels made of aluminum or other suitable metals may be applied with dielectric materials lying between them.

30 The individual levels may be planarized using chemical-mechanical polishing, for exemplary, in a single polishing step, in particular, for example, only for the second sealing level.

ABSTRACT OF THE DISCLOSURE

A method of manufacturing a micromechanical component includes the steps of providing a substrate, providing a first micromechanical functional layer on the sacrificial layer, structuring the first micromechanical functional layer so that it is provided with a mobilizable sensor structure, providing and structuring a first sealing layer on the structured first micromechanical functional layer, providing and structuring a second micromechanical functional layer on the first sealing layer which has at least a covering function and is at least partially anchored in the first micromechanical functional layer, making the sensor structure movable and providing a second sealing layer on the second micromechanical functional layer. A corresponding micromechanical component is also described.

FIG 1

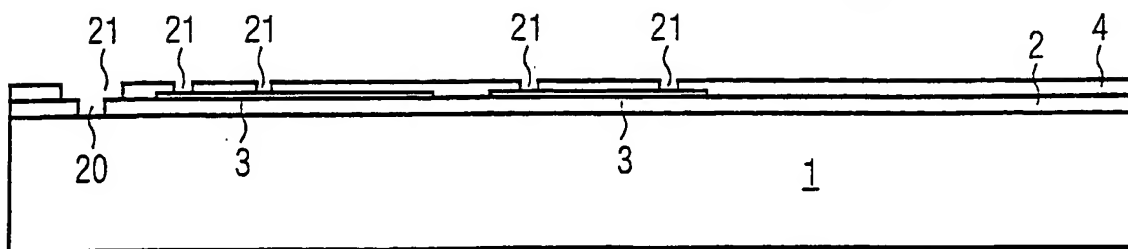


FIG 2

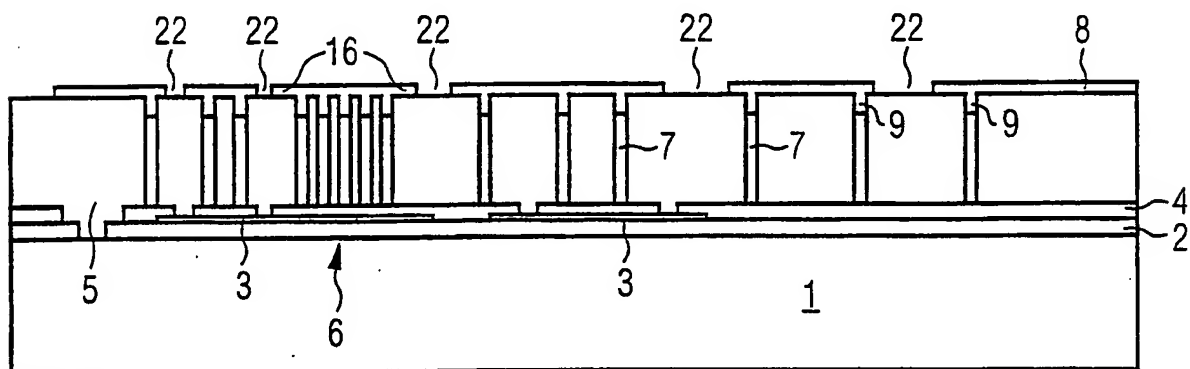


FIG 3

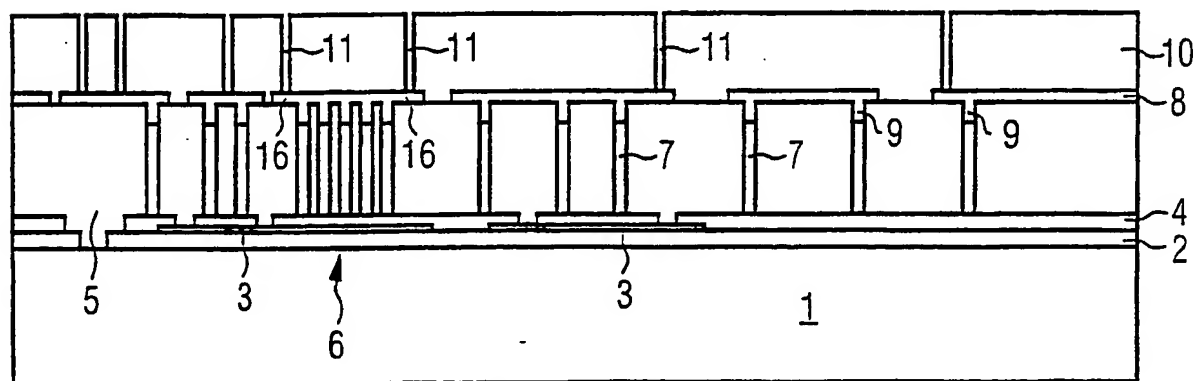


FIG 4

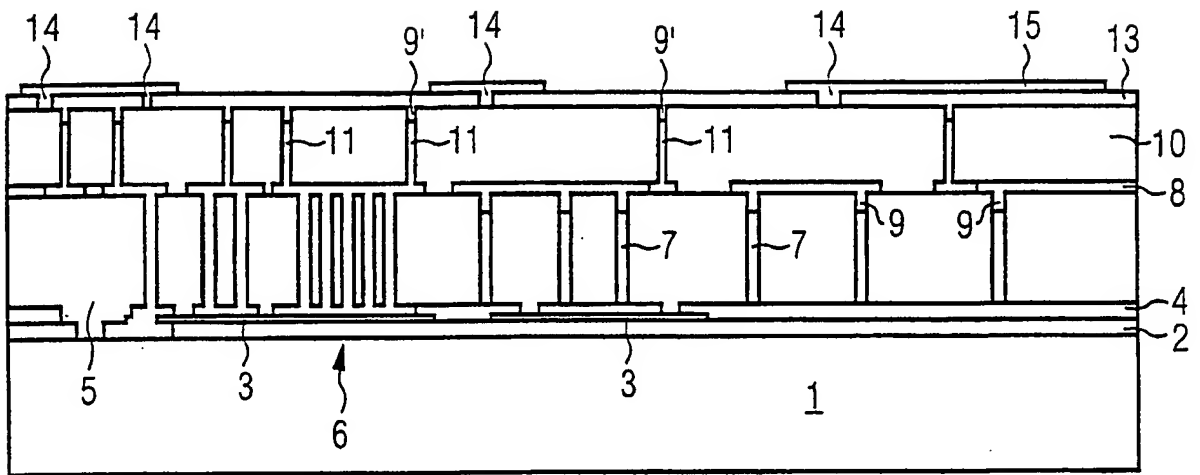


FIG 5

